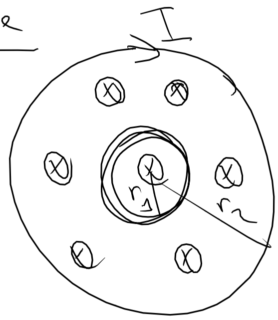
Hand in your HW!

Example



$\Phi = MI$

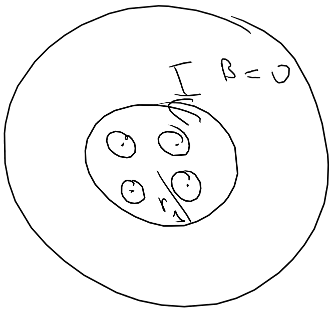
$B = \mu_0 I n$

n: # of ~~turns~~ turns per length of the outer solenoid.

$\Phi = B(\pi r_1^2) N$

N: # of turns of the inner solenoid.

Example



$B = \mu_0 I n_{in}$

$$\phi_{out} = \int \vec{B} \cdot d\vec{S}$$

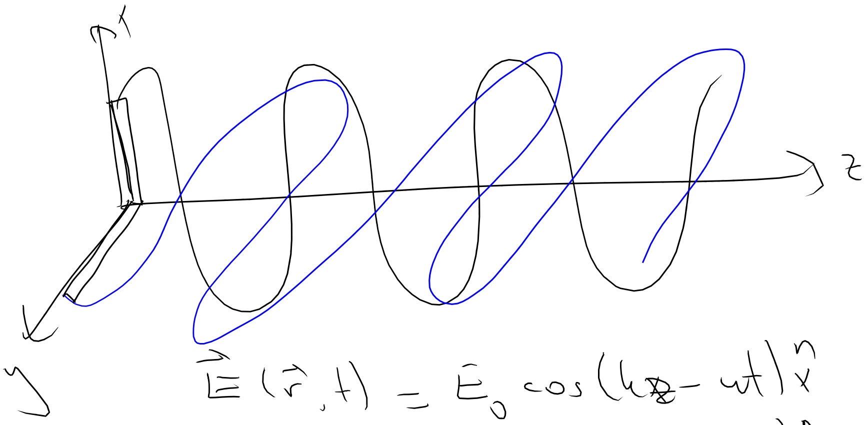
$$= \int_{inner} \vec{B} \cdot d\vec{S} + \underbrace{\int_{in\ between} \vec{B} \cdot d\vec{S}}_{\text{}}$$

0 =

$$= B(\pi r_1^2) N_{out}$$

$$\oint \vec{E} \cdot d\vec{l} = 0 \iff \vec{E} \text{ is conservative}$$

$$\oint \vec{E} \cdot d\vec{l} = -\frac{d\phi_B}{dt}, \text{ if } \frac{d\phi_B}{dt} \neq 0 \iff \vec{E} \text{ is non conservative}$$



$$\vec{E}(\vec{r},t) = E_0 \cos(kz - \omega t)\,\hat{x}$$

$$\vec{B}(\vec{r},t) = B_0 \cos(kz - \omega t)\,\hat{y}$$

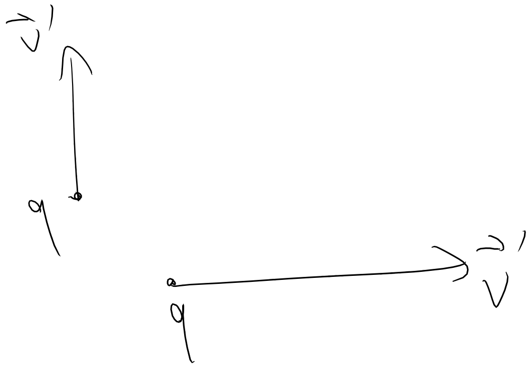
$$\frac{E_0}{B_0} = c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

Fourier Thm

Taylors Thm $f(x) = \sum a_n (x - x_0)^n \qquad a_n = \frac{1}{n!}\frac{d^n f}{dx^n}\Big|_{x=x_0}$

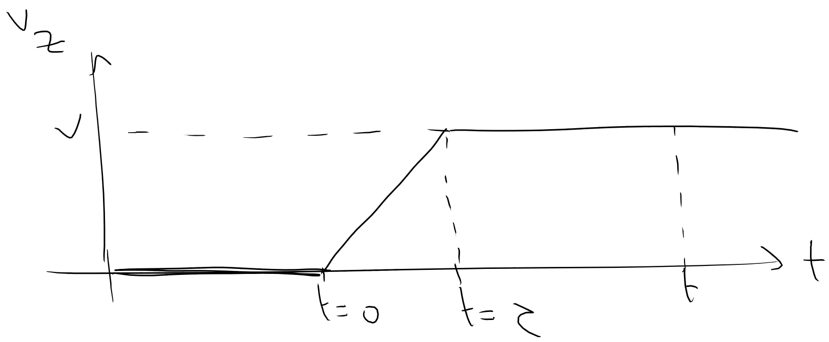
Fourier Thm $f(x) = \sum \sin, \cos$

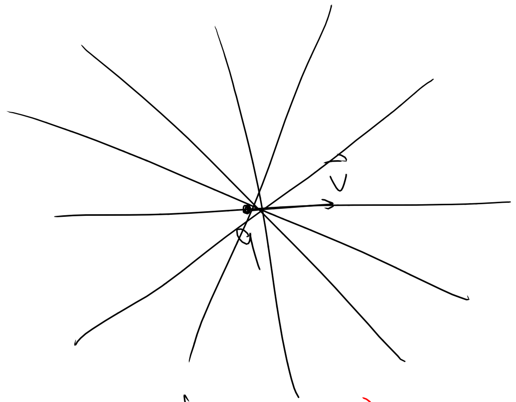
How to create EM waves?



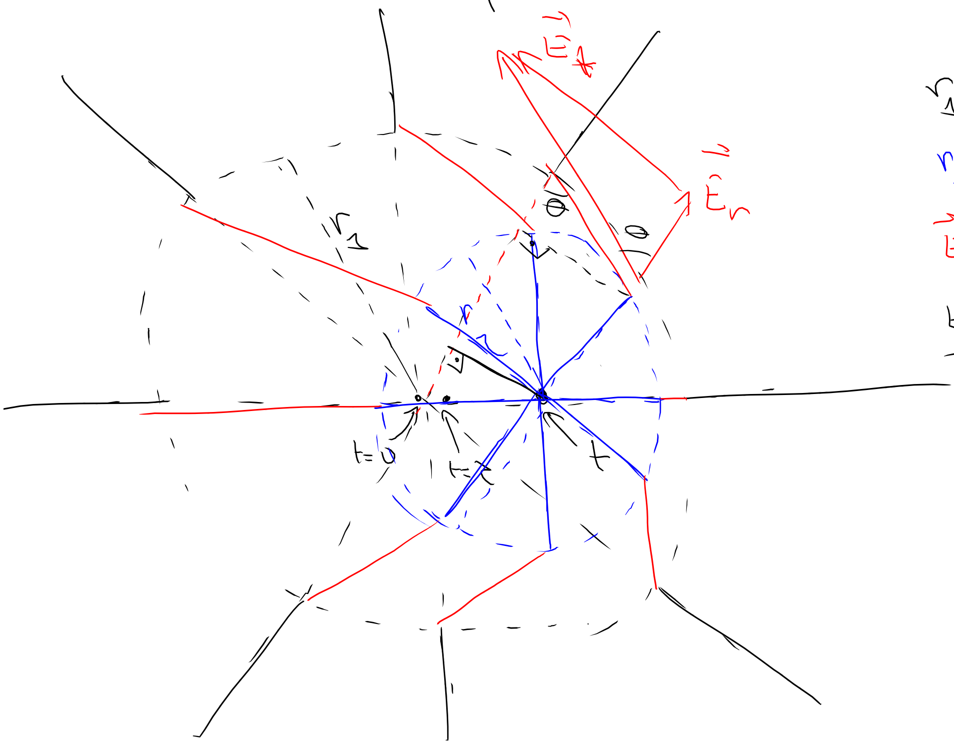
Accelerated charges

$$\vec{a}(t) = \hat{x}\begin{cases} a_0 & 0 < t < \tau \\ 0 & \text{otherwise} \end{cases} \qquad v_{max} \ll c$$





$v \lll c$

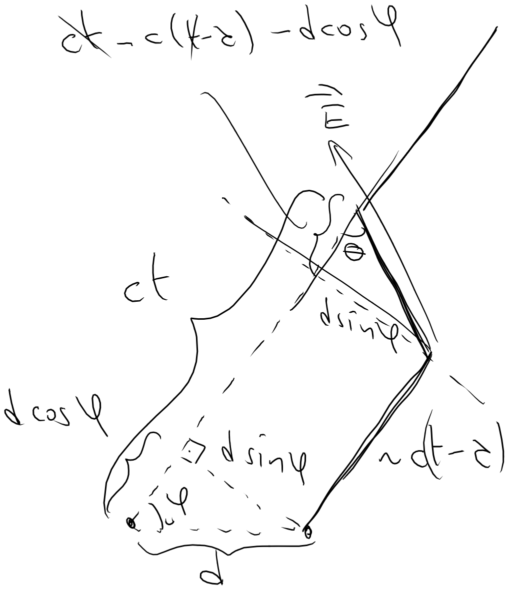


$r_1 = ct$

$r_2 = c(t-\tau)$

$\vec{E} = \vec{E}_r + \vec{E}_t$

$$\frac{E_t}{E_r} = \tan\theta$$



$$d \simeq vt$$

$$\tan\theta = \frac{d\sin\varphi}{c\tau - d\cos\varphi} = \frac{E_t}{E_r}$$

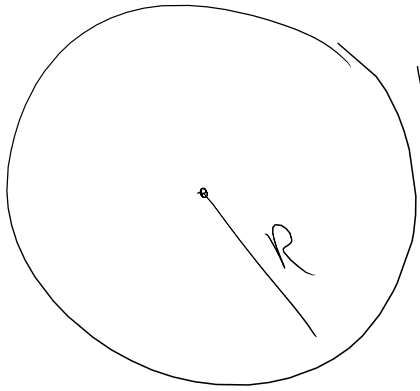
$$E_t = E_r \frac{d\sin\varphi}{c\tau - d\cos\varphi}$$

$$\boxed{E_t = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\frac{d\sin\varphi}{c\tau - d\cos\varphi}}$$

$$E_r \sim \frac{1}{r^2} \qquad \vec{S} \propto \vec{E}\times\vec{B}$$

radiation field

$$\left.\begin{aligned} E_t &\sim \frac{1}{r} \quad (?) \\ B_t &\sim \frac{1}{r} \end{aligned}\right\} \quad S \propto \frac{1}{r^2}$$



$$\lim_{R\to\infty} \oint \vec{S}\cdot d\vec{A} = \text{constant}$$

$$E_t = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\frac{d\sin\varphi}{c\tau - d\cos\varphi} \simeq \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\frac{vt\sin\varphi}{c\tau}$$

$$E_t \simeq \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\frac{a\,t\sin\varphi}{c}$$

$$t = \frac{r}{c} \Rightarrow r = ct$$

$$E_t \simeq \frac{1}{4\pi\varepsilon_0}\frac{qa\sin\varphi}{c^2}\frac{1}{r}$$

$$E_t(\vec{r},t) \simeq \frac{1}{4\pi\varepsilon_0 c^2}\frac{1}{r}\, q \sin\varphi \; a\left(t-\frac{r}{c}\right)$$

$$t-\frac{r}{c} \simeq 0 \qquad a\left(t-\frac{r}{c}\right) = a \neq 0$$

$$E_t \neq 0$$

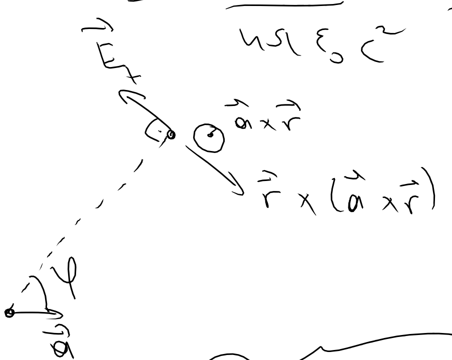
$$a(t) = \begin{cases} a & \text{if } 0<t<\tau \\ 0 & \text{otherwise} \end{cases}$$

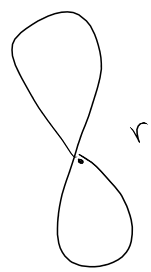
$$I_{AC} = I_0 \cos(\omega t) \Rightarrow a(t) = a_0 \cos(\omega t)$$

$$E_t(\vec{r},t) \simeq \frac{1}{4\pi\varepsilon_0 c^2}\frac{1}{r}\, q \sin\varphi \; a_0 \cos\left(\omega\left(t-\frac{r}{c}\right)\right)$$

$$= \frac{1}{4\pi\varepsilon_0 c^2}\frac{1}{r}\, q \sin\varphi \; a_0 \cos(\omega t - kr)$$

$$k \equiv \frac{\omega}{c}$$

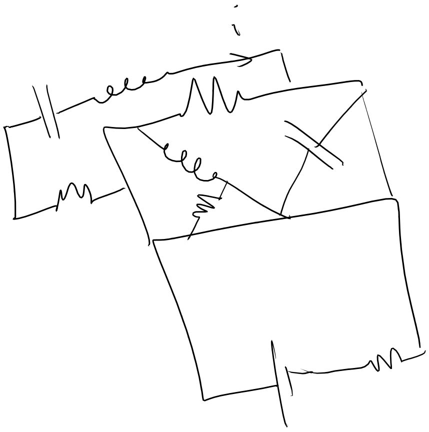




$$E_t = \frac{q}{4\pi\varepsilon_0 c^2}\, \overbrace{r\, a\left(t-\frac{r}{c}\right) \sin\varphi}\, \frac{1}{r^2} = \frac{q}{4\pi\varepsilon_0 c^2}\frac{1}{r^2}\left|\vec{a}\times\vec{r}\right| \overset{\vec{a}\times\vec{r}}{\odot}$$

$$\boxed{\vec{E}_t = \frac{q}{4\pi\varepsilon_0 c^2}\frac{1}{r}\overbrace{(\vec{a}\times\hat{r})\times\hat{r}}^{\hat{r}\times(\vec{a}\times\hat{r})}} \qquad \vec{a}\left(t-\frac{r}{c}\right)$$

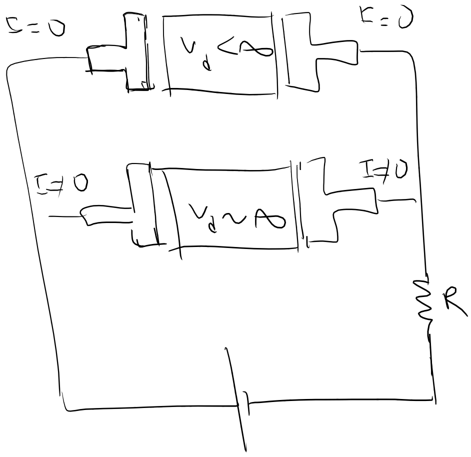
short circuit

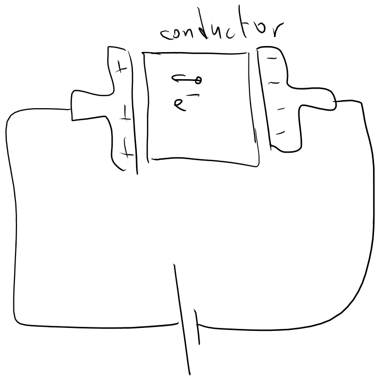


$i = ?$

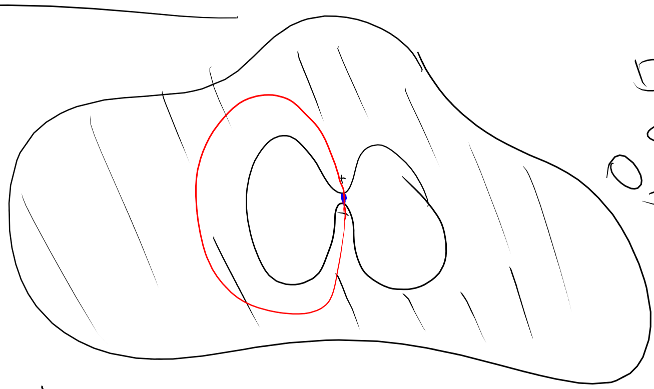
$i = 0$

$\rho \propto \frac{1}{V_d}$





Electrostatics



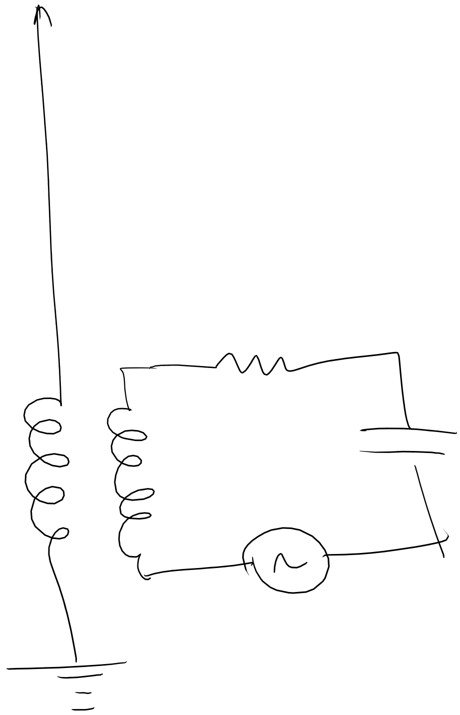
hence, this configuration is not possible!

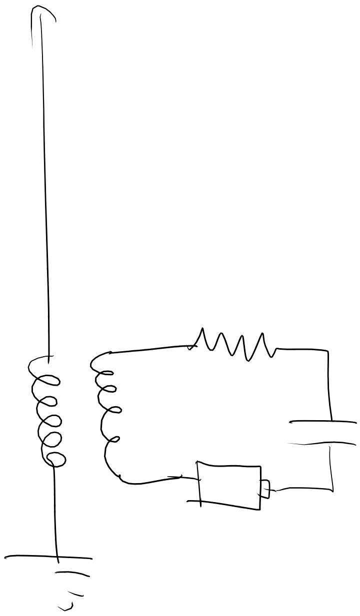
$$\oint \vec{E}\cdot d\vec{l} = -\frac{d\Phi_B}{dt} = 0$$

If $\vec{E} \neq 0$ in the cavity

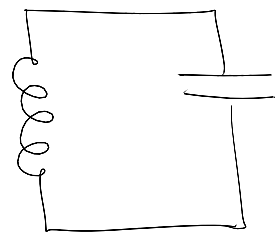
$$0 = \oint \vec{E}\cdot d\vec{l} = \underbrace{\int_{\text{in the cavity}} \vec{E}\cdot d\vec{l}}_{\neq 0} + \underbrace{\cancel{\int_{\text{in the conductor}} \vec{E}\cdot d\vec{l}}}_{0}$$

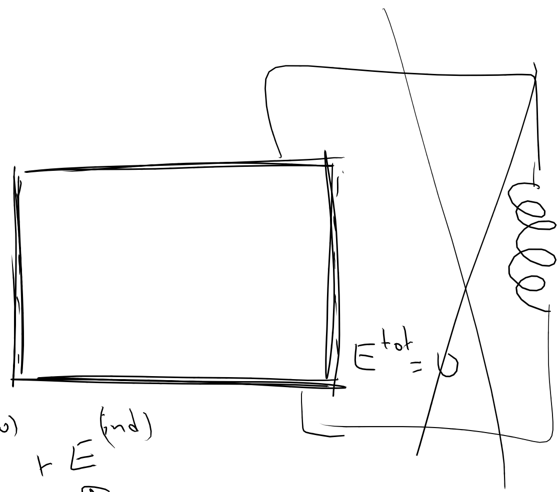
$\neq 0$!!!



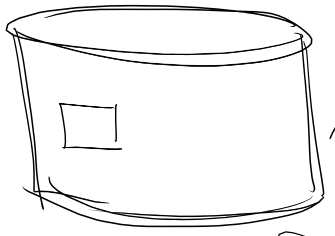


$$0 \neq \oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$$





$$E^{tot} = \underbrace{E^{(\omega)}}_{\text{const}} + \underbrace{E^{(ind)}}_{\text{increases with distance from the center}}$$



electromagnetic cavity

superconducting cavity.

accelerators